AIM-Monitoring:

A Component of the BLM Assessment, Inventory, and Monitoring Strategy

BLM

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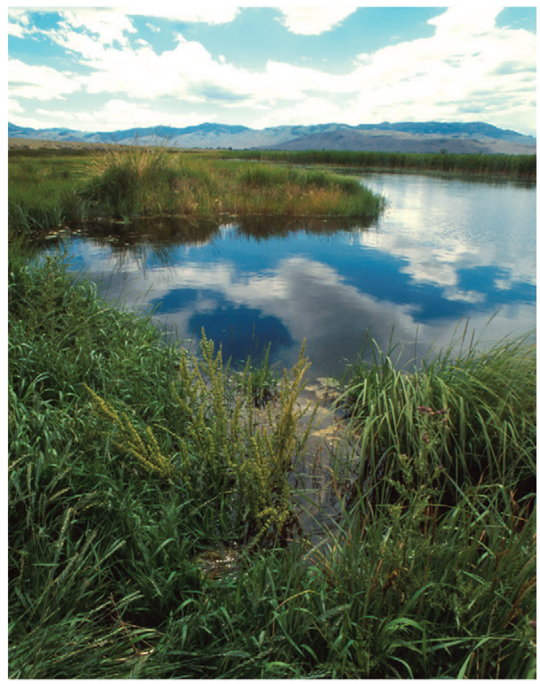

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High-Quality Information

High-quality information on the status, condition, and trend of natural resources is essential for making sound land management decisions. The Bureau of Land Management (BLM) collects this information through an array of resource assessment, inventory, and monitoring efforts that support the bureau's diverse, multiple-use land management needs.

All management levels of the BLM rely on monitoring data to derive essential resource information. At the field level, monitoring information is used in developing land use and activity plans and for designing and assessing virtually all resource management projects (e.g., vegetation treatments, fire recovery efforts, livestock grazing, energy development and extraction, recreation activities, etc.). At the regional level, monitoring information is used to detect landscape-scale resource status and trend and to help focus and coordinate field management efforts within and across jurisdictional boundaries. Monitoring information is also used at the national level to report on overall resource status, condition, and trend and to direct management capacity where it's most needed.

The Need for a New Monitoring Approach

BLM monitoring efforts have historically been developed to meet specific project and program objectives at the field level. However, because individual monitoring efforts were developed at different times for varied purposes, they commonly did not share standard approaches. As a result, even when current monitoring efforts fulfill local management or program-specific needs, much of the information cannot be readily compared through time, across management areas, combined with monitoring data from different programs, or aggregated to provide regional or national perspectives on resource status, condition, and trend or management effectiveness. In other cases, current monitoring efforts are not fulfilling the full range of management needs or not doing so as effectively as possible.

The rate of change and the amount of use on public lands are at unprecedented levels. Deriving the knowledge of how ecosystems are changing, which is necessary to guide and justify management, use, or policy actions, necessitates consistent data that can serve many monitoring objectives and can be aggregated for use across multiple scales of management (from field to national levels). Given capacity constraints and the sheer number of monitoring needs, it is no longer possible to implement individual monitoring and assessment plans for each identified threat or use.

AIM-Monitoring: A National, Integrated Monitoring Approach

The "BLM Assessment, Inventory, and Monitoring Strategy for Integrated Renewable Resources Management" (AIM Strategy) was completed in 2011 in response to a request from the Office of Management and Budget. The strategy describes an approach for integrated, cross-program assessment, inventory, and monitoring of renewable resources (e.g., vegetation, soils, water, and wildlife habitat) at multiple scales of management. Following the AIM Strategy, the BLM is modernizing its resource monitoring approach to more efficiently and effectively meet local, regional, and national resource information needs. The AIM Strategy provides a process for the BLM to collect quantitative information on the status, condition, trend, amount, location, and spatial pattern of renewable resources on the nation's public lands, from individual field office levels, to public lands across the Western U.S. and Alaska. Each AIM-Monitoring survey, at any scale of inquiry, uses a set of core indicators, standardized field methods, remote sensing, and a statistically valid study design to provide nationally consistent and scientifically defensible information to track changes on public lands over time.

AIM-Monitoring consists of five primary elements:

- A structured implementation framework (see Figure 1) built on management questions and conceptual models of ecosystem structure and function;
- A standard set of core and contingent quantitative indicators and methods that can be supplemented for locally specific needs;

Process Model	Implementation Steps
Frame the Issue	• Identify management question(s). • Define study areas and determine scale of effort (national, regional, local). • Review regulatory requirements (Federal Land Policy and Management Act, resource management plans, standards, etc.).
Understand the System	• Review existing literature and models. • List key ecosystem components, interactions, and processes essential for system sustainability. • List drivers related to system functioning. • Review relevant local/traditional knowledge. • Review AIM conceptual model. • Create regionally specific conceptual model; adapt/add detail related to listed processes, drivers, and needs to the AIM model.
Develop Objectives	• List regulatory requirements and program needs, including land health fundamentals and standards. • Consider key ecological elements (defined by the conceptual model), management questions, and regulatory requirements. to ensure core indicators and methods fulfill needs. - Add SMART (specific, measurable, achievable, relevant/repeatable, time sensitive) supplemental indicators as necessary. • Develop SMART monitoring objectives related to core and supplemental indicators.
Assemble Background/ Existing Information	• Review and assemble existing research to support supplemental indicators and methods. • Identify related, existing, and legacy monitoring efforts. • Identify existing reference/base data (e.g., to support sample stratification).
Develop Monitoring and Sampling Schema	• Refine the study area. • Identify potential data collection approaches for selected indicators. -Field and/or remote sensing based. • Choose sample design, stratification, and intensity. • Generate unbiased sample points.
Create and Finalize Monitoring Plan	• Define and document protocol decision rules for replacing sample points, locating and laying out plots, and collecting/recording data. • Optimize data collection (field and/or remote sensing). • Finalize/approve monitoring plan. • Develop/approve monitoring implementation plan.
Implement Data Collection and Management	• Implement monitoring plan and collect data. • Perform quality assurance/quality control and data stewardship. • Upload data to national monitoring database. • Review, approve, and replicate to production database.
Analyze and Report	• Analyze/evaluate data against monitoring objectives and/or land health standards. • Communicate results as appropriate. • Complete annual reports.
Adaptive Management	• Analyze monitoring results in annual reports against resource objectives and conceptual model. • Adapt activities, models, and monitoring plan as necessary. • Incorporate lessons learned into future activities and management actions.

Figure 1. AIM-Monitoring implementation framework

- A statistically valid, scalable sampling design;
- Integration of remote sensing monitoring technologies; and
- Electronic, onsite data capture and centralized data management.

A fundamental tenet for AIM-Monitoring is that information can be collected once and used many times for many reasons across many programs (e.g., recreation, grazing, energy, wildlife, and wild horse and burro management). Further, these data can be easily compared and combined to simultaneously address a wide range of local, regional, and national (i.e., multiscale) management needs. All AIM-Monitoring deployments are intended to achieve five goals determined to be important to land managers, from field to national levels.

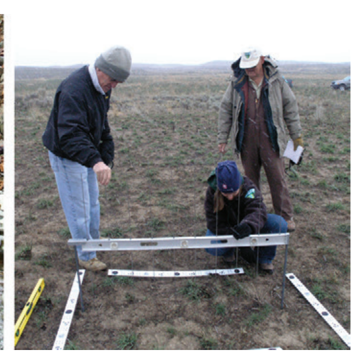
The five goals of each AIM-Monitoring deployment include:

1. Determine the status, condition, and trend of priority resources and key ecosystem components and processes.
2. Determine the location, amount, and spatial pattern of priority resources, key ecosystem components and processes, disturbances, and other changes on the landscape.
3. Provide a conceptual understanding of key ecosystem components, processes, and sustainability concepts that should be incorporated into land use plans, National Environmental Policy Act (NEPA) documents, cumulative effects analyses, etc.
4. Generate quantitative and spatial data to address goals 1 and 2 and to contribute to existing land health assessment and evaluation processes at multiple scales of inquiry.
5. Generate quantitative and spatial data that are necessary to defensibly determine if management actions (e.g., land treatments) are moving resources toward desired states, conditions, or specific resource objectives identified in planning or related documents or legal mandates.

Deploying AIM-Monitoring: A Structured Implementation Framework

Deploying AIM-Monitoring means engaging in a process (hereafter referred to as the implementation framework) to develop a monitoring plan designed to meet resource information needs. The AIM-Monitoring implementation framework (see Figure 1) consists of nine primary and iterative steps. The implementation framework begins by defining management questions, identifying key ecological components and processes of the system to be managed, and developing ecosystem conceptual models (see Figure 2). By combining management needs with the processes critical to functioning ecosystems, monitoring objectives can be defined. Relevant monitoring efforts and scientific literature are reviewed and incorporated into the process. Various approaches and rules for data collection are defined. The implementation steps are documented in an approved monitoring plan and data collection begins. Once collected, data are managed and analyzed within the BLM's national geospatial infrastructure, where they can contribute to management decisionmaking, determinations of management effectiveness, and local, regional, and national reporting efforts. Collectively, AIM-Monitoring information provides a basis for land managers to adaptively manage resources,



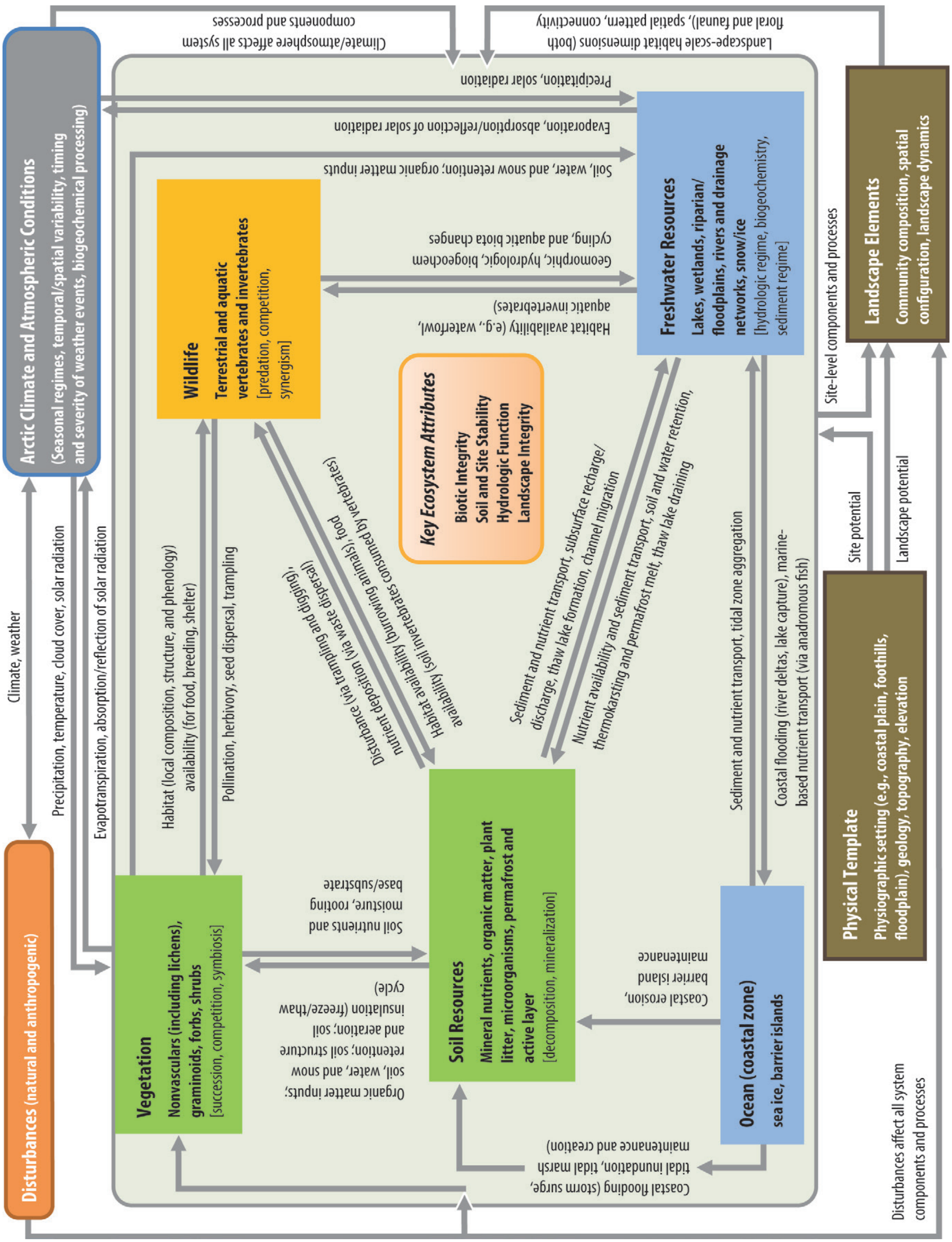


Figure 2. A conceptual ecosystem model depicting ecosystem drivers/change agents (rounded corners), key ecosystem components (rectangles), within-component interactions and processes (brackets), and between-component interactions and processes (arrows) for the North Slope of Alaska. This peer-reviewed conceptual model was developed in conjunction with the Alaska Natural Heritage Program to support an AIM-Monitoring deployment in the National Petroleum Reserve-Alaska. Development of conceptual ecosystem models is a critical step of "understanding the system," which is step number two in the AIM-Monitoring implementation framework (see Figure 1).

improve understanding of the ecosystem, and adjust monitoring efforts as necessary using a well-documented and consistent approach.

What to Measure: Core and Contingent Indicators of Ecosystem Sustainability

Healthy, sustainable ecosystems support the diverse multiple uses of public lands. The AIM Strategy monitoring component has identified broadly applicable (i.e., cross program, cross scale, and cross ecosystem), field-based quantitative monitoring measurements called *core and contingent indicators of terrestrial ecosystem sustainability* (see Table 1). These core terrestrial indicators provide information needed to understand the status, condition, and trend of terrestrial ecosystems managed by the BLM. Efforts are currently underway to add several remote sensing-based core indicators and methods to support mapping and monitoring of landcover and wildlife habitat. Efforts are also underway to select core and contingent indicators of aquatic ecosystem sustainability, which will be introduced in a future BLM technical note.

Table 1. Core and contingent terrestrial indicators and monitoring methods

TYPE	INDICATOR	METHOD	WHERE APPLIED?
Core	Amount of bare ground	Line-point intercept (LPI) for foliar cover, supplemented with plot-level species inventory	All terrestrial ecosystems managed by the BLM
	Vegetation composition		
	Nonnative invasive species		
	Plant species of management concern		
	Vegetation height	Height at selected LPI points	
	Proportion of site in large, intercanopy gaps	Canopy gap intercept	
	* Landcover (habitat) amount, location, and pattern	Remote sensing acquisition and spatial pattern metrics	
	* Aquatic indicators		
Contingent	Soil and site stability		When necessary
	Soil toxins		
	*Others (e.g., stand density index, wildlife metrics, etc.)		

* In development

The field-based core and contingent terrestrial indicators were selected following a review of BLM monitoring efforts nationwide, interagency input, and a conceptual ecosystem modeling process based on three key attributes of ecosystem sustainability (including biotic integrity, site/soil stability, and hydrologic function). The importance of spatial landscape characteristics to ecosystem sustainability has led to the addition of a fourth key attribute, landscape integrity. These four key attributes, along with their associated terrestrial and aquatic core indicators, will always be measured when an AIM-Monitoring design is deployed, regardless of the program or management area where monitoring data are being collected. Lastly, contingent and/or supplemental indicators are measured when necessary to address specific local, regional, or national resource needs or objectives.

Where to Measure: A Statistically Valid, Scalable Sampling Design

AIM-Monitoring indicators and methods are designed to be "scalable." A scalable monitoring design allows information to be collected by local resource managers to meet local management needs and to be combined with data collected elsewhere to address broader, landscape-scale, and national reporting needs. Scalability requires not only consistent indicators and methods, but also a statistically valid sample design. A statistically valid sample design, in the context of AIM-Monitoring, means that the management/study area for monitoring is explicitly defined (e.g., a recreation area or stream segment), sample locations are randomly selected within meaningful sampling strata (e.g., ecological sites), and that every location within the management/study area has at least some chance of being sampled.

How to Measure: Consistent Methods for Collecting the Indicators

Resource monitoring information is most valuable when it is collected repeatedly in a consistent manner over long periods of time. This is a challenging goal because many resource professionals in diverse locations conduct resource monitoring using different methods over different lengths of time. To accomplish long-term consistency and scalability of results, AIM-Monitoring establishes standardized methods for collecting data necessary to derive the core and contingent indicators of ecosystem sustainability. These core and contingent monitoring methods (see Table 1) were selected because they are objective, repeatable with minimal observer bias, easy to implement, well documented, and widely used. Further, these methods reflect the knowledge and experience of scientists, rangeland managers, and ecologists from many different agencies and institutions.

How to Measure: Remote Sensing

Remote sensing refers to the acquisition of resource data collected by any device (e.g., satellites or low-flying aircraft) not in direct contact with the object of interest. The AIM Strategy and AIM-Monitoring emphasize the importance of using remote sensing as a monitoring tool to improve monitoring efficiency. Field-only data provide precise, statistically valid measures of resource status and trend through time. Additionally, field data provide a valuable source of data to "train" and validate remote sensing products. In turn, remote sensing data can extend the utility of some field data by providing the location, amount, and spatial pattern of resources and the status, condition, and trend of these resource attributes across broad geographic extents.

By taking advantage of recent advances in remote sensing science, traditional field-only renewable resource measures (consistent with the AIM core indicators) can be collected using very-high-resolution, 3-dimensional remote sensing imagery. By optimizing the integration of field and remote efforts, field personnel will reduce the number of field samples needed to detect resource changes, focus data collection efforts in areas experiencing high levels of change, and collect data in isolated locations that are difficult to access. Further, integrating field and remote sensing efforts will reduce costs, improve the BLM's ability to monitor large and diverse landscapes, and detect landscape changes (e.g., disturbance and climate effects) at multiple scales.

Interpreting Measures: Using Monitoring Data to Determine Land Condition

Interpreting the status, departure, or rate of change of renewable resources to determine condition requires comparison of data collected via field sampling and/or remote sensing against indicators of ecological attributes for reference conditions. These reference conditions must be based on site or landscape potential.

Ecological site descriptions (ESDs) describe the potential of a site to support different types and amounts of vegetation, determined by factors like soils, climate, and landform. Ecological sites react

to factors like disturbance or degradation (historic or current), which can lead to alternative stable plant communities outside the historic potential of the site. Elements of an ESD that are helpful for defining reference conditions and interpreting departure from reference conditions include: state-and-transition conceptual models of plant community changes in response to disturbance or management; descriptions of the range of plant communities that could exist on the site in addition to the potential vegetation; descriptions of anthropogenic and natural disturbances and their potential to cause changes in plant communities; descriptions of dynamic soil properties (e.g., organic matter content, soil aggregate stability), and soil cover (e.g., bare ground).

ESDs are the basic units for stratifying landscapes for site-level AIM-Monitoring efforts and are also fundamental for most terrestrial upland land health standards and land health evaluations in the BLM. While ESDs are the foundation upon which AIM-Monitoring data are evaluated, efforts are currently underway to determine methods for describing current and reference resource conditions based on land potential at broader scales using a combination of field and remote sensing data.

Putting AIM-Monitoring into Practice: National Landscape Monitoring, Demonstration Areas, and Related Projects

Using the AIM-Monitoring core indicators and methods, in cooperation with the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), the BLM deployed the first year of its Westside Landscape Monitoring Framework (LMF) in 2011. The LMF is a low-intensity sampling effort, collecting approximately 1,000 sample plots per year across BLM-managed public lands. (The LMF is limited to nonforested public lands because the U.S. Forest Service's Forest Inventory and Analysis program provides resource information of all forested lands regardless of ownership or management agency.) The LMF has three primary functions. The first function is to provide regional-scale, statistically valid estimates of terrestrial/upland rangeland resource status, condition, and trend to provide valuable reference conditions for local decisionmaking. The second function is to provide a framework upon which all locally driven monitoring efforts can be tied, ensuring all BLM-managed lands are covered by a monitoring program. The third function is to provide consistent data necessary to improve the accuracy of national landcover/vegetation mapping, which will increase the utility of this mapping for local vegetation management, planning, and decisionmaking.

The broad applicability and cross-program utility of the AIM-Monitoring core indicators and methods allow for relatively rapid deployment to meet emerging management needs. Such is the case with the BLM's management of greater sage-grouse habitats. Working in conjunction with the NRCS, the BLM is increasing the sampling density of the LMF across the range of the greater sage-grouse to increase our understanding of the status, condition, and trend of these habitats. Importantly, collection of these habitat-specific AIM-Monitoring data is being driven by sage-grouse management questions, but these data are not limited to sage-grouse use in the future. These same data can be used for other wildlife habitat questions and also for recreation, grazing, and climate change effects, to name a few.

Several field-level deployments of AIM-Monitoring for both aquatic and terrestrial ecosystems are underway (see Figure 3). These projects include energy, grazing, sage-grouse, wild horse and burro, postfire restoration, and National Landscape Conservation System (NLCS) management areas in multiple states. AIM-Monitoring is also being implemented on landscape-scale projects in Nevada and Alaska to address specific management needs, to validate that the core indicators are applicable to all ecosystems managed by the BLM, and to ensure that site-level monitoring information can be readily combined to address management questions at broader scales.

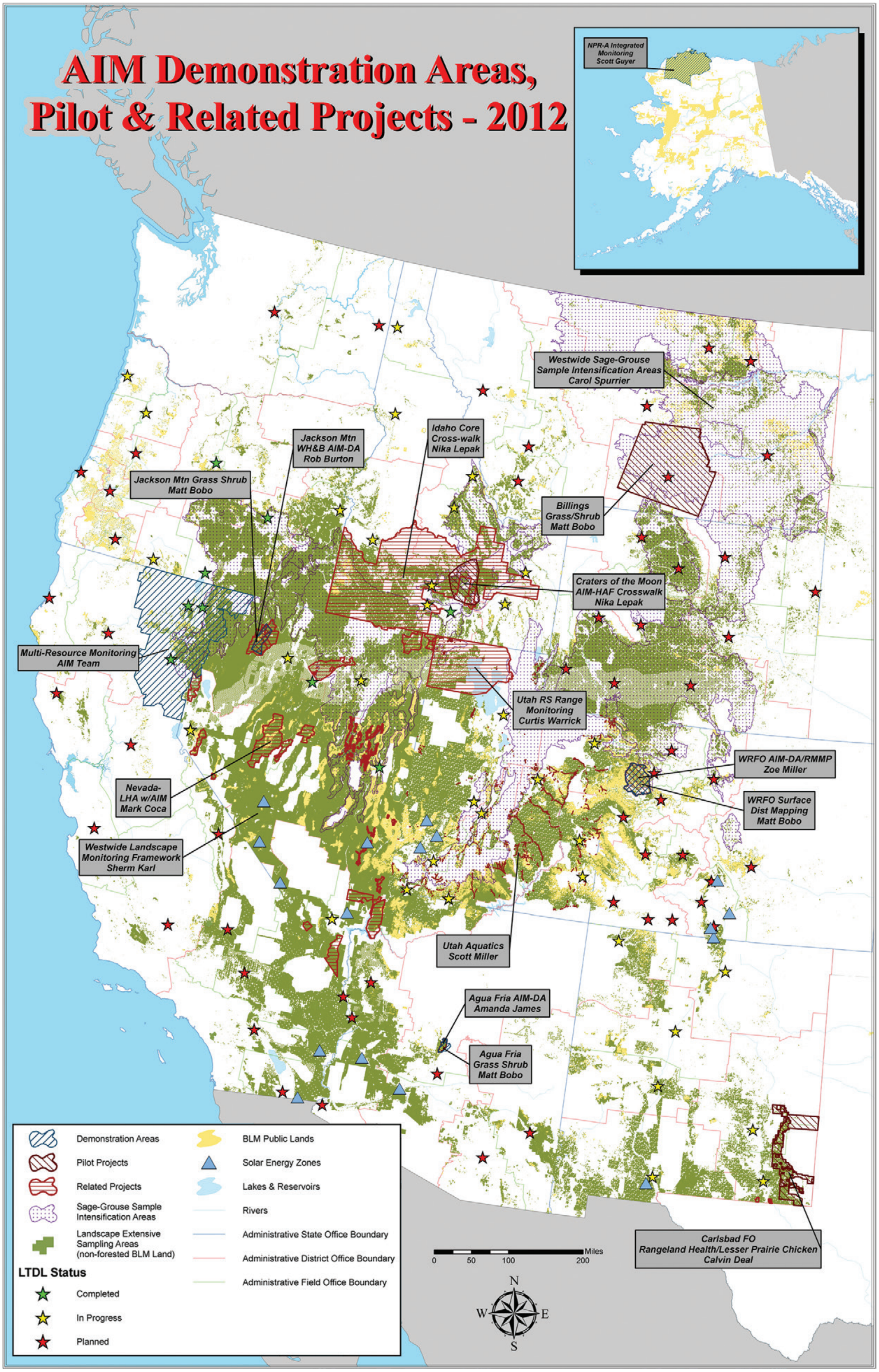


Figure 3. AIM demonstration areas, pilot and related projects – 2012

Integration of Legacy Monitoring Data

Previously collected (i.e., legacy) monitoring data remain an essential part of the BLM's monitoring framework. To ensure the longevity of these legacy data, BLM personnel are working with statisticians at the USDA Agricultural Research Service and Iowa State University to understand how to best integrate legacy data into AIM-Monitoring-derived products. Further, several pilot efforts are exploring the integration of AIM-Monitoring information with data-rich "key area" and other legacy efforts. Lastly, the BLM is supporting the development of a Land Treatment Digital Library to capture, store, and analyze historical land treatments by all BLM offices in the West. Much work remains in this area, but the BLM remains committed to ensuring the longevity and utility of its legacy monitoring efforts.

Monitoring for Adaptive Management

The BLM will use information derived from AIM-Monitoring to make necessary management adjustments to meet resource objectives described at project, activity plan, resource management plan, and/or national program levels. Reporting at multiple scales will inform decisionmakers on the effectiveness of management actions, opportunities for adaptive management, refinement of conceptual models, and evaluating the monitoring program itself. Adaptive changes will be subject to environmental analysis, land use planning, and public involvement, as appropriate.

Related Documents

- Bureau of Land Management Assessment, Inventory, and Monitoring Strategy for Integrated Renewable Resources Management
- BLM Technical Note 440: BLM Core Terrestrial Indicators and Methods
- BLM Technical Note 439: Developing a Resource Management and Monitoring Protocol for a Semi-Arid Landscape with Extensive Oil and Gas Development Potential
- Society for Range Management, "Rangelands" journal article: Consistent Indicators and Methods and a Scalable Sample Design to Meet Assessment, Inventory, and Monitoring Information Needs Across Scales
- BLM Geospatial Services Strategic Plan
- AIM Implementation Framework
- AIM "Base" Conceptual Models
- AIM Nationwide Projects Map
- AIM Nationwide Projects Descriptions

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